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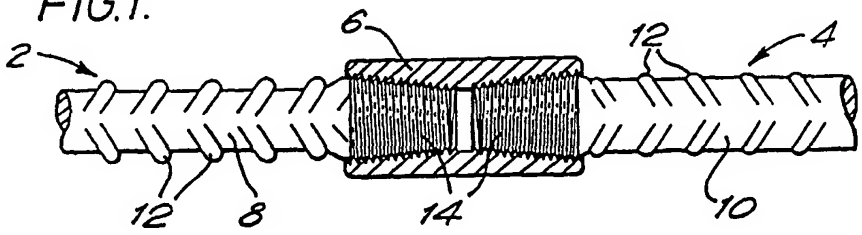
(54) Concrete reinforcement bar couplings and apparatus for enlarging bar ends

(57) A concrete reinforcement bar (2, 4) has enlarged ends upon which tapering external threads (14) are formed. The ends are adapted to be received in couplers (6) so that an extended bar or mesh formation of bars can be assembled. Apparatus for enlarging the bar ends has a holding member (22) with jaws (28) for clamping the bar (4) with its end (44) protruding towards a ram (38). The ram is operable to advance a ram head (42) into engagement with the protruding bar end (44) to enlarge the cross-section thereof.

FIG.1.



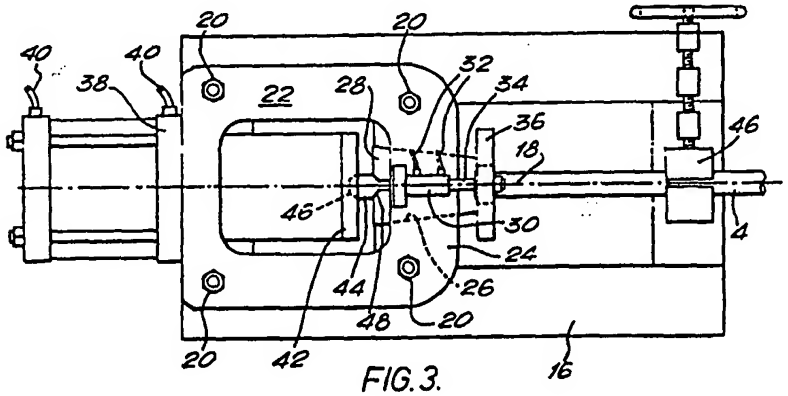


FIG.3.

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

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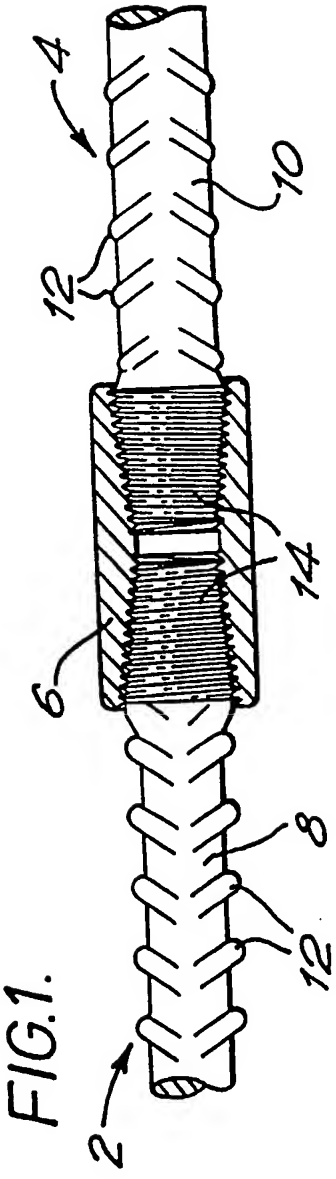

FIG.1.

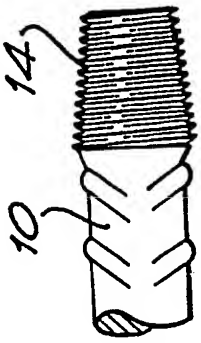

FIG.2C.

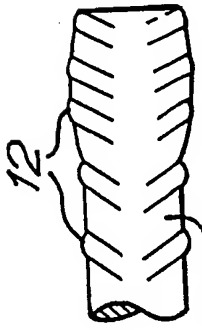

FIG.2B.

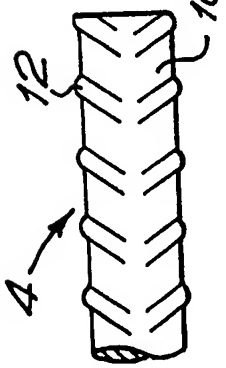

FIG.2A.

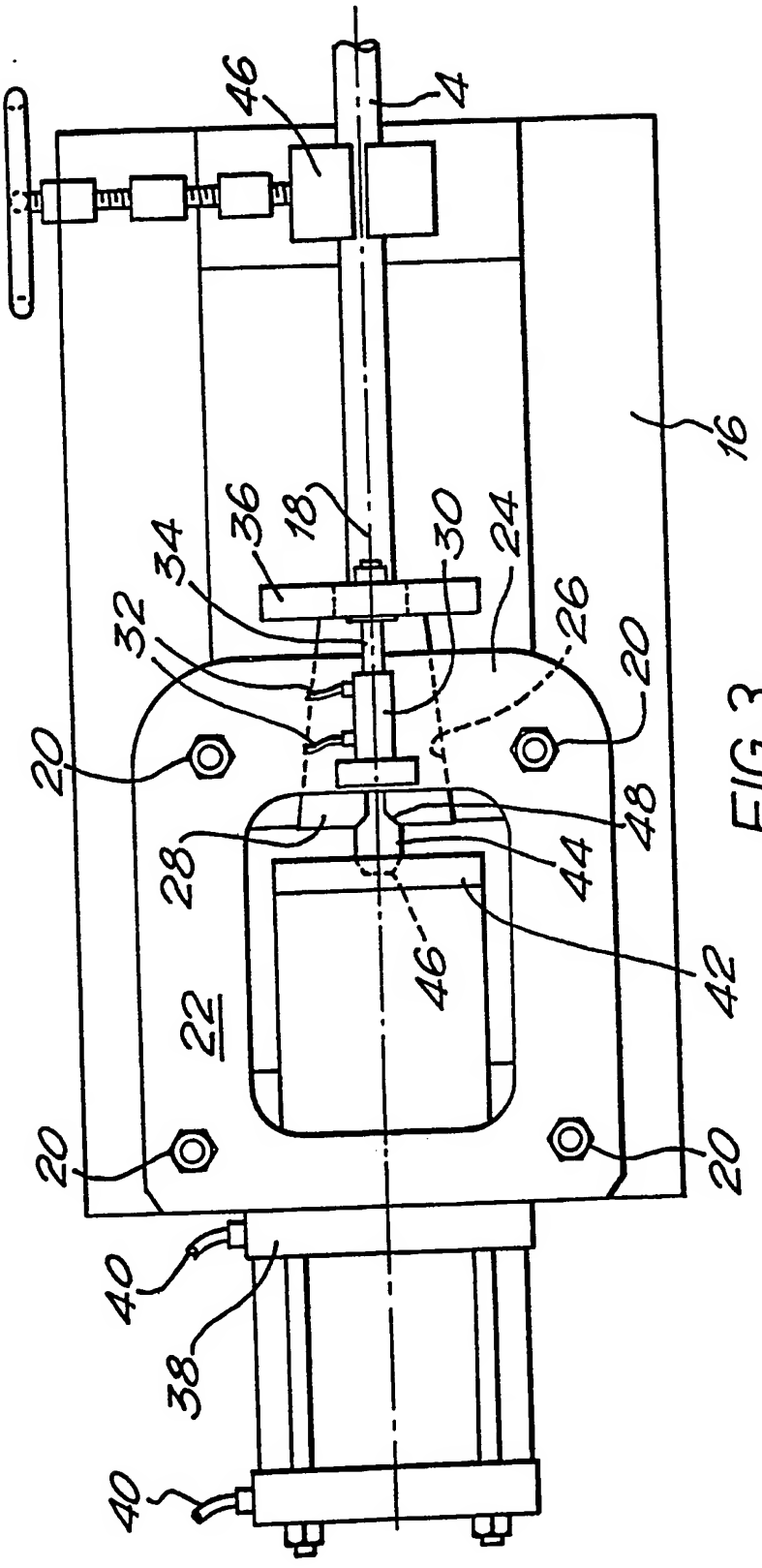

FIG. 3.

Concrete Reinforcement Bars and Couplings therebetween

This invention relates to reinforcement bars and means by which they may be adapted for coupling to each other and to surrounding formwork in a reinforced concrete element. It relates particularly to the end of such bars and their adaptation to receive a male screw thread thereon.

In the production of concrete elements, it is well established to reinforce the concrete by casting it around reinforcement bars. It is often necessary to align a number of reinforcement bars, and in order to achieve the best results, such bars should be linearly coupled. In some circumstances, it can be desirable to couple more than two bars at a single junction, or to couple a bar at the periphery of the element to forework or some external construction. To achieve such coupling, various techniques have been developed, and one that is frequently adopted uses a screw thread formed on the external surface of reinforcement bars at one or both ends thereof which is received in a tubular coupler. The coupler may have a female screw thread formed at either end thereof to enable two bars to be connected in line.

While the above technique has been successfully adopted, the use of threaded couplings have the disadvantage that the tensile strength of such coupled bars is normally limited by the strength at the threaded coupling; and particularly by the strength of the threaded end of a bar. The reason for this is that the male thread normally cuts into the core of the bar and thereby reduces its effective cross-section. To meet this problem, coupling systems have been adopted in which the end of each bar is enlarged relative to the cross-section of the bar elsewhere, and the thread formed exclusively on the enlarged bar end. There are though, difficulties in enlarging the end of concrete reinforcement bars that enables the satisfactory f rmation of a male parallel screw thread thereon.

The present invention is directed at a coupling system for reinforcement bars and related techniques which takes advantage of the benefits of enlarged bar ends as described above, but reduces the work required to form an enlarged end prior to formation of a screw thread thereon. To this end, a concrete reinforcement bar according to the invention having a substantially uniform cross-section intermediate its ends is enlarged at at least one end thereof relative to such intermediate cross-section and formed with a tapering external male thread on the enlarged end. Normally, the mean root diameter of the thread is at least equal to the diameter of the intermediate cross section of the bar, and preferably the minimum root diameter of the external thread is at least equal to the diameter of the intermediate cross-section of the bar. Essentially, the invention provides that a substantial axial length of the tapered thread has a root diameter at least equal to the diameter of the intermediate bar cross-section.

The adoption of a tapered thread on an enlarged bar end has a number of advantages. Primarily, the enlargement of a bar end by cold or hot working tends to result in a slight taper in any event, and thus by applying a tapered thread less working is required to achieve sufficient enlargement to apply the thread thereto. The axial length of the thread in which the root diameter is greater than the intermediate diameter also strengthens the subsequent coupling where the potential tensile forces are likely to be greatest. Additionally, the step of coupling itself is simplified. Whereas a parallel thread must be screwed along its entire length and against some form of stop, which may be another bar already installed in the coupling, a tapered thread can be tightened in much fewer turns, and is self-locking when the root diameters of the male and female threads are match d.

Reinforcement bars according to the invention are almost invariably of metal, and normally formed in steel.

Ends thereof can be enlarged by cold or hot working, although cold working is preferred. Bars are also usually hardened at the surface, and the enlargement technique adopted should be such as to at least retain the surface properties.

A coupling system between reinforcement bars according to the invention will have the end of each bar received in a coupler having a complementary female tapering thread formed in each of at least two openings therein. The openings in the coupler will normally be aligned, and usually contiguous. The female threads may be of the same or opposite senses depending on the threads formed on the bar ends and the particular application. Usually the female threads in the coupler will be of the same sense, as will the male threads on the bars, for ease of manufacture, and for ease of assembly of the system. A coupler may of course have more than two openings, any or all of which can receive a bar end. For example, a coupler may have four orthogonally oriented openings if the reinforcement bars are to be laid in a mesh formation.

We have found that when testing coupling systems of the invention, the systems failed intermediate the bar ends rather than at or adjacent the couplers, as was the case with previous systems. Failure at or adjacent the coupler was also found to be the case with bars with tapered threads formed on ends thereof which had not been enlarged relative to the intermediate cross-section of the respective bar.

The present invention also relates to apparatus for forming an end portion on a reinforcement bar with an enlarged cross-section relative to the bar cross-section intermediate its ends. Apparatus according to this aspect of the invention comprises a frame defining an axis; an holding member traversing the frame and formed with an opening substantially aligned with the frame axis, the wall of the opening tapering in one direction along the axis; a plurality of jaws disposed in the

opening and adapted to clamp the reinforcement bar therebetween upon movement into the opening in one direction; and a ram fixed relative to the holding member. The ram is operable to advance a ram head along the frame axis towards the jaws, and means are provided for locating a reinforcement bar along the frame axis with an end thereof protruding from the jaws and towards the ram end. Operation of the ram successively advances the ram head into engagement with the protuding bar end, and the jaws into the opening to clamp the bar therein, so as to reduce the protuding length of the bar end and thus enlarge the cross-section thereof against the closed jaws. Provision is normally also made for moving the jaws into the opening to grip a bar therein prior to operation of the ram to ensure th. the advance of the ram head does not eject the bar th. ough the opening. Any suitable device may be used for this purpose, but normally both the ram and the device will be fluidic or hydraulic, and actuated from the same source of fluid under pressure.

In order to ensure the proper formation of the enlarged end on the bar, in apparatus according to the invention either or preferably both of the ram head and the jaws will be provided with a recess located substantially on the axis of the frame to receive the axial extremities of the enlarged end portion. The recess on the ram will normally be closed at the base thereof. That on the jaws will be in the form of corresponding plurality of depressions in the inner edges of the jaws which together form a substantially annular recess. In some cases, bevelled or chamfered edges on the jaws will be sufficien~ in this respect.

The jaws in apparatus according to the invention will normally have an external surface which substantially matches the internal surface of the opening in the holding member, but the internal surface which engages the r inforcem nt bar may take any suitable form. It may be deliberatey roughened or formed with teeth so

as to enhance its grip on the bar, although particularly where the bar itself is formed with ribs or some other surface projections, this can be unnecessary. In one preferred embodiment of the invention, the internal surfaces of the jaws define a plurality of planar surfaces surrounding the frame axis. In a particularly preferred embodiment, two jaws are used which together define four substantially orthogonal planar surfaces surrounding the frame axis.

In operating apparatus according to the invention, the advance of the ram head should preferably be controlled to achieve the desired degree of deformation of the bar end. This can be in response to the pressure developed at the engagement with the bar end or, as is preferred, by the location of a limit switch set a chosen distance from the exposed face of the jaws. This latter technique has the advantage of accommodating dimensional irregularities in the bar itself, and of course prevents the ram head from advancing against the jaws in the event of unintentional operation or failure of the jaws to properly clamp the bar.

When using apparatus according to the invention, after enlargement of the bar end and withdrawal of the ram head, the jaws may remain in clamping engagement around the bar within the opening in the holding member. Provision may also be made for forcing the jaws out of the opening and towards the withdrawn ram head, and where a preliminary gripping device is employed as discussed above, this may be adapted to operate in a reverse mode to this end.

The invention will now be described by way of example and with reference to the accompanying diagrammatic drawings wherein;

Figure 1 shows in partial cross-section two r inforcement bars received in a tubular coupler;

Figures 2A, 2B and 2C show successive stages in the formation of a tapered male thread on th enlarged end of

the reinforcement bar; and

Figure 3 shows a plan view of apparatus according to the invention for enlarging a bar end.

Figure 1 shows the end of two slightly different concrete reinforcement bars 2, 4 connected to the same coupler 6. Each bar 2, 4 has a core 8, 10 with a pluarality of partially circumferential projections 12 thereon. Both bar ends are enlarged relative to the bar cross-section remote from the coupler 6, and are provided with tapered screw threads 14 on the enlarged sections. The thread 14 on the bar 2 is right handed. The thread 14 on the bar 4 is left handed. The overall dimensions, pitch and taper of the thread 14 is the same on each bar end. A standard 60° thread with a 2mm pitch is suitable, although other thread geometries may be adopted. The coupler 6 is formed with corresponding right and left handed threads enabling it to be turned in one direction to simultaneously tighten the threaded connection with each bar 2, 4.

The bars 2, 4 shown in Figure 1 differ only in the base diameter of the respective cores 8, 10. The diameter of the core 8 in bar 2 is less than the diameter of the core 10 in bar 4. More particularly, the diameter of the core 8 is equal to or less than the minimum root diameter of the thread 14 at the end of bar 2. The diameter of core 10 is substantially equal to or less than the mean root diameter of the thread 14 on bar 4. Thus, in the formation of the threads 14 on the bars 2 and 4, the relative enlargement of the bar 2 at its end relative to the core diameter is greater than that required for bar 4.

It should be noted that Figure 1 illustrates two bars of different core diameter connected to the same coupler 6 for the purpose of illustration only. While in some applications, bars of different core diameters would be coupled in this way, it is unusual. Generally, the core diameter and thread on a reinforcement bar will be

adapted for use with only one size of coupler to ensure that only reinforcement bars of one core diameter are used in a given application. It is normally not recommended for on-site work to use couplers with opposite threads, and threads of the same sense will usually be used at both end of the coupler, so that couplers and bars can be successively connected by screwing onto one another in the same sense.

The tapered threads 14 define a specific limit of the depth to which each bar 2, 4 can be screwed into the coupler 6. It will also be appreciated that the body of the coupler 6 could be extended in one or more additional directions to form further openings for receiving threaded bar ends if desired.

Figure 2A shows the end of a bar prior to the formation of a thread 14 thereon. The bar comprises a core section 10 of substantially uniform cross-section, with ribs 12 projecting from the surface thereof. Figure 2B shows the bar end after it has been cold worked to enlarge the end section thereof. As can be seen, the ribs 12 have been brought closer together in the enlarged section, where the diameter of the core 10 has been increased by around 20%. To achieve this degree of deformation, the initial length of the section to be enlarged is normally around two times the bar core diameter, and this length is reduced by around 25% to achieve the desired core diameter enlargement.

As is apparent from Figure 2B, the shape of the enlarged end section of the bar has a slightly bowed profile, with the maximum core diameter developing substantially centrally within the axial length of the enlarged section. An enlarged bar end as shown in Figure 2 is thus not readily suitable for the formation of a parallel thread thereon. Figure 2C shows the enlarged bar end of Figure 2B in which a tapering thread 14 had been cut or roll formed thereon. It will be readily apparent that the minimum pitch diameter of the thread 14 is 1 ss than the minimum diam ter at the end of the

enlarged section of Figure 2B , enabling the thread to be directly cut thereon. As noted above, Figures 2 show a bar similar to that identified as 4 in Figure 1, in which the minimum root diameter of the thread 14 is less than the diameter of the core 10. This is also apparent from Figure 2C where it will be recognised that the mean root diameter of thread 14 is substantially equal to the diameter of the core 10. It should be noted though, that even at the exposed end of the enlarged section of the bar as shown in Figure 2B the diameter is greater than the core diameter, enabling the minimum root diameter of the thread 14 to be at least equal to the core diameter, thereby forming an enlarged or upset bar end 2 as shown on the left in Figure 1.

Figure 3 shows in schematic elevation apparatus according to the invention for enlarging or upsetting the end of a bar 4 to form an enlarged end section of the kind illustrated in Figure 2B. The apparatus comprises a frame 16 which defines an axis 18. Mounted on the frame 16 by bolts 20 is an holding member 22, a portion 24 of which traverses the frame 16 and the axis 18. In the portion 24 is formed a conical opening with its larger end directed to the left as shown. Installed within the opening 26 is a plurality of jaws 28 with external conical surfaces which complement the wall of the opening 26 such that upon movement to the right as shown into the opening 26 the jaws converge upon the axis 18.

Also mounted on the portion 24 of the holding member 22 is a hydraulic cylinder 30 with connections 32. A piston 34 extends from the cylinder 30 to a bracket 36. The cylinder 30 may be actuated to urge the bracket 36 to the left as shown along the axis 18 to release the jaws 28 from the opening 26 as will be described below.

Also mounted in the frame 16, and fixed relative to the holding member 22 is an hydraulic ram 38. With connections 40. The ram has a ram head 42 which is in juxtaposition with the exposed faces of the jaws 28 along the axis 18. The connections 40 are connected to a

source of fluid under pressure, and actuation of the ram urges the head 42 to the right as shown along the axis 18. A limit switch (not shown) may be mounted either on the holding member 22 or the end face of a jaw 28 to prevent excessive advance of the ram head 42. The limit switch may be coupled to the connections 40 or the source of fluid under pressure to depressurise the ram when it reaches the specified limit of advance. Typically, the limit switch is set to act in response to the spacing between the exposed face of the jaws 28 and the ram head 42 falling below say 4 mms.

In use of the apparatus shown in Figure 3, a reinforcement bar 4 is located in the frame 16 with its end 44 protruding from the exposed face of the jaws 28 as shown. Additional support for the bar 4 is provided remote from the holding member 22 by an adjustable clamp 46. The clamp 46 is adapted to only lightly engage the bar 4. It is adjustable so as to accommodate bars of differing diameter, but should not substantially restrict the movement of the bar 4 along the axis 18. With the bar 4 mounted in the apparatus, and the ram head 42 withdrawn, the protruding length of the bar end 44 is adjusted to approximately twice the bar diameter. The jaws 28 are then moved to the right while retaining the protruding length of the bar end 44 at this value, until the bar is firmly held in the opening 26. Normally, this is accomplished by reverse operation of the cylinder 30, with the bracket 36 suitably flexibly coupled to the ends of the jaws 28. With the bar so held, the ram 38 is actuated, and the ram head 42 moves to the right as shown along axis 18, up to and beyond its engagement with the bar end 44. Its progessive advance beyond engagement with the bar end 44 deforms the end while simultaneously applying an axial force to the jaws 28 which tightens their radial engagement with the bar 4 in the opening 26. The ram 38 will normally have a capacity around 150 tonnes, and the apparatus described will normally be suitable for bars of diameter in the range 16mm to 40mm.

The degree of advance of the ram head 42 will be selected according the degree of enlargement requir d at the bar end 44. Once this is reached, the ram is depressurised and the ram head 42 withdrawn. The cylinder 30 is then activated to urge the jaws 28 to the left as shown, enlarging the space between them to an extent sufficient to withdraw the enlarged bar end 44 therethrough to the right as shown along the axis 18. Upon being urged to the left, the jaws 28 will normally be separated as they are carried over the enlarged end. However, resilient spring mechanisms may be deployed to draw them outwards as they are released. Alternatively, they may be mounted in guideways on the wall of the opening 26 which retains them on convergant paths of movement at all times.

In order to preserve the alig. ment of the bar end on the axis 18, the ram head 42 is formed with a recess 46 for receiving the end, and the inner edges of the jaws 28 facing the ram head 42 are beveled or chamfered. The provision of these features extends the length of the bar end that can protrude from the jaws 28 without risk of excessive deformation. Normally though, the protruding length should not exceed 2.5 times the diameter of the bar 4.

CLAIMS

1. A concrete reinforcement bar having a substantially uniform cross-section intermediate its ends, wherein at least one end thereof is enlarged relative to such intermediate cross-section and formed with a tapering external male thread.

2. A reinforcement bar according to Claim 1 wherein the mean root diameter of the tapering thread is at least equal to the diameter of the intermediate cross-section of the bar.

3. A reinforcement bar according to Claim 1 or Claim 2 wherein the minimum root diameter of the tapering thread is at least equal to the diameter of the intermediate cross-section of the bar.

4. A concrete reinforcement bar substantially as described herein with reference to Figures 1 and 2 of the accompanying drawings.

5. A coupling system between reinforcement bars, according to any preceding Claim, wherein a said end of each bar is received in a coupler having an internal tapering thread complementary to that on said end formed in each of at least two openings therein.

6. A coupling system according to Claim 5 wherein the coupler has two substantially aligned said openings.

7. A coupling system according to Claim 6 wherein the sense of the internal thread in one opening is the same as that of the thread in the opening aligned therewith.

8. A coupling system according to any of Claims 5 to 7 wherein the openings in the coupler are contiguous.

9. A coupling system according to any of Claims 5 to 8 wherein the coupler has more than two openings receiving more than two bar ends.

10. A coupling system according to Claim 9 wherein the coupler has four orthogonally ori nted openings.

11. A coupling system substantially as described herein with reference to Figures 1 and 2 of the accompanying drawings.

12. Apparatus for working an end portion of a reinforcement bar, which bar has a substantially uniform cross-section intermediate its ends, to form an end portion on the bar with an enlarged cross-section relative to said intermediate cross-section, the apparatus comprising a frame defining an axis; a holding member traversing the frame and formed with an opening therethrough substantially aligned with said axis, the wall of the opening tapering in one direction along said axis; a plurality of jaws disposed in the opening and adapted to clamp a said reinforcement bar therebetween upon movement into the opening in said one direction; a ram fixed relative to the holding member, the ram being operable to advance a ram head along said axis in said one direction; and means for locating a reinforcement bar along said axis of the frame with an end thereof protruding from the jaws in the other direction along said axis, whereby operation of the ram successively advances the ram head into engagement with the bar end, the jaws into the opening to clamp the bar therein, and reduce the protruding length of the bar end to enlarge the cross-section thereof.

13. Apparatus according to Claim 12 wherein the locating means comprises means for moving the jaws in said one direction to close the jaws around a bar extending therebetween in the opening.

14. Apparatus according to Claim 13 wherein at least one of the ram and the moving means comprises a fluidic device.

15. Apparatus according to any of Claims 12 to 14 wherein the locating means includes a gripping device mounted on the frame remote from the holding member.

16. Apparatus according to any of Claims 12 to 15 wherein the ram head has a recess formed in the face thereof f r receiving a said bar end.

17. Apparatus according to any of Claims 12 to 16 wherein the jaws are formed with recesses at the inner edges thereof facing the ram head for receiving a portion of the enlarged end of a said bar upon formation thereof.

18. Apparatus for working an end portion of a reinforcement bar, substantially as described herein with reference to Figure 3 of the accompanying drawings.

19. A method of forming an enlarged end on a reinforcement bar having a substantially uniform cross-section intermediate its ends, which method comprises locating the bar on the axis of the frame in apparatus according to any of Claims 12 to 18 with an end thereof protruding from the jaws towards the ram head; moving the faces in said one direction to close the jaws around the bar; and activating the ram to advance the ram head and engage and compress the protruding bar end to enlarge the cross-section thereof relative to said uniform cross-section, such advance further urging the jaws into the opening in the holding member to tighten the engagement of the jaws around the bar and prevent axial movement thereof in said one direction.

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